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Three-point volatility smile classification: Evidence from the Warsow Stock Exchange during volatile summer 2011

Juan J. García-Machado [a,*], Jarosław Rybczyński [b]

[a] University of Huelva, Plaza de La Merced, 11, E-21071 Huelva, Spain
[b] University of Silesia In Katowice, Ul. 75 PulkuPiechoty 1, 11, 41-500 Chorzów, Poland

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ABSTRACT

This paper studies the behavior of the smile in the Warsaw Stock Exchange (WSE) during the volatile summer of 2011.We investigate the volatility smile derived from liquid call and put options on the Polish WIG20 index which option series expired on September 2011. In this period, the polish index has dropped about 20% in two weeks time. By linear interpolation, implied volatilities for moneyness points needed were calculated, then we construct 355 smile curves for calls and puts options to study and make some kind of smile-types classification. We propose seventeen types-smiles which represent all possible cases of three points (three moneynesses) graphical patterns. This classification is made basing upon relationship higher/equal/lower values of implied volatility for each of three points. Furthermore, we distinguish the convexity of pattern. We can note that smiles, smirks and ups are convex in shape, while reversed ones and downs are concave functions.

Clasificación de las Sonrisas de Volatilidad según tres puntos de monetización: evidencia empírica para la Bolsa de Varsovia durante el volátil verano de 2011

RESUMEN

Este artículo analiza el comportamiento de la sonrisa de la volatilidad en la Bolsa de Varsovia (WSE) durante el volátil verano de 2011, derivada de las opciones más líquidas sobre el índice polaco WIG20, cuyas series expiraron en septiembre de 2011. En ese período, el índice había caído aproximadamente un 20% en tan sólo dos semanas. Mediante interpolación lineal construimos 355 curvas de sonrisas para poder estudiar una posible clasificación o tipología de las mismas. Proponemos 17 tipos de sonrisas, las cuales representan todos los casos posibles de tres monetizaciones de patrones gráficos. Esta clasificación se basa en la relación valores superiores/iguales/inferiores de la volatilidad implícita para cada uno de los tres puntos. Además, se distingue la convexidad de cada una. Destacamos que las sonrisas completas, las sonrisas asimétricas y las inclinadas hacia arriba son de forma convexa, mientras que las invertidas y las inclinadas hacia abajo son funciones cóncavas.

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1. Introduction

Volatility measures how much prices move. The direction of the move, whether up or down, is irrelevant. The magnitude and the speed of the change are most important. In the futures and options markets, the implied volatility is often used, which refers how much

* Corresponding author.
E-mail addresses: machado@uhu.es, jjgarmachado@gmail.com (J.J. García-Machado).

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the market anticipates price changes and is reflected on the prices of contracts. Implied volatility is used independently or together with historical volatility and other different methodologies (Stochastic volatility models, GARCH[1] models, EWMA,[2] etc.) to estimate the future volatility (see Covring & Low, 2003 and Wong & Tu, 2009, for instance). Whereas historical volatilities are "backward looking", implied volatilities are "forward looking". According to Duque and Teixeira Lopes (2003), the "Smile effect" is a result of an empirical observation of the options' implied volatility, with the same expiration date, across different exercise prices. It typically describes a U-shape form showing high implied volatility patterns for in and out-of-the-money options (ITM & OTM) and low volatility figures for at-the-money options (ATM), that is, the implied volatility is relatively low for ATM options, but becomes progressively higher as an option moves either into the money or out of the money.

In this paper, we investigate the volatility smile derived from call and put options on the Polish WIG20 index, the nearest to expiring date, which are the most heavily traded and fluid index options in the Warsaw Stock Exchange. We also look into the procedures to obtain implied volatilities in order to compare different smiles and provide a pattern of them in the Polish market.

The paper is organized as follows. We start by reviewing the related literature as theoretical background. Next we describe the methodology in use and data. Finally, we present the empirical results and conclusions.

2. Theoretical background

Over the years, it has become quite clear that the market does not price all options according to the Black–Scholes formula (Mayhew, 1995). The consensus opinion is that the model performs reasonably well for ATM options with one or two months to expiration and this experience has motivated the choice of such options for calculating implied volatility. For other options, however, the discrepancies between market and Black–Scholes prices are large and systematic. Because the Black–Scholes model holds reasonably well for some options and not for others, different options on the same underlying security must have different Black–Scholes implied volatilities. It is well known that the implied volatilities of options differ systematically across strike price and across time to expiration. The pattern of implied volatilities across times to expiration is known as the "term structure of implied volatilities", and the pattern across strike prices is known as the "volatility skew" or the volatility smile. If we combine the skew with the term structure, we will obtain what is called "volatility surface".

The earliest papers that found evidence for volatility smiles described how Black–Scholes pricing errors vary systematically with strike price or with time to expiration. Macbeth and Merville (1979), for example, reported that the Black–Scholes model undervalues ITM and overvalues OTM call options. Subsequent authors found the contrary result, that the Black–Scholes model undervalues OTM calls. These and other relevant results are summarized by Galai (1983).

The most systematic and complete study documenting volatility smiles is that of Rubinstein (1985), whose most robust result is that for OTM calls implied volatility is systematically higher for options with shorter times to expiration. His other results were statistically significant but changed across subperiods. Thus, systematic deviations from the Black–Scholes model appear to exist, but the pattern of deviations varies over the time. Culumovic and Welch (1994) found the same results using more recent data in a similar study.

Subsequent studies by Sheikh (1991) and by Heynen (1994) used Rubinstein's nonparametric tests to examine implied volatility patterns in index options. Sheikh found smile effects using transactions data for OEX call options from March 1983 to March 1987. Heynen examined the implied volatility of European Options Exchange (EOE) stock index options. Using Rubinstein's approach and transaction data from January 23 to October 31, 1989, he found systematic smile effects, including a U-shaped term structure of implied volatility.

Many other authors found evidence for volatility smiles and non-flat term structures of implied volatilities in various markets. Shastri and Tandon (1986), for example, used Geske and Johnson approach (1984) to price American options on futures and found volatility smile and term structure effects in the markets for options on S&P 500 futures and on Deutschemark futures. Xu and Taylor (1994) examined the term structure of volatility implied by options on four Philadelphia Stock Exchange currency options using data from 1985 to 1989. Heynen, Kemna, and Vorst (1994) examined the ability of various GARCH models to explain the observed term structure of implied volatilities. McKenzie, Gerace, and Subedar (2007) evaluated the probability of an exchange traded European call option being exercised on the ASX200 Options Index.

Related literature studies how the economic variables associated with the options market affect the volatility shape (Bollen & Whaley, 2004; Deuskar, Gupta, & Subrahmanyam, 2011; Dumas, Fleming, & Whaley, 1998; Ederington & Guan, 2002; Heynen et al., 1994; Hull & White, 1987; Jarrow, Li, & Zhao, 2007; Peña, Rubio, & Serna, 1999, 2001; Rompolis & Tzavalis, 2010).

Duque and Paxson (1994) found the smile effect for options traded on the London International Financial Futures and Options Exchange (LIFFE) during March 1991. Gemmill (1996) also found the same effect for options on the FTSE 100 during a 5-year period (from 1985 to 1990), although the smile showed different patterns for different days extracted from the sample. Dumas, Fleming, and Whaley (1998) also found empirical smile patterns for options on the S&P 500 stock index, but its shape seemed to be asymmetric and changing along time to maturity. Peña, Serna, and Rubio (1999) also found empirical smiles for stock index options written on the IBEX-35, for a time period between 1994 and 1996, detecting a day of the week effect for the smile. Low (2000) using the implied Market Volatility Index (VIX) of the Chicago Board Options Exchange (CBOE) found empirical evidence for the association between market conditions and volatility. However, his findings point to an asymmetric behavior for this relationship. Carverhill, Cheuk, and Dyrting (2002) showed evidence of the "smirk", when studying deep away-from-the money index options. Lim, Martin, and Martin (2002) presented evidences for relatively symmetric imperfections (as it is regularly pointed out to the currency market) with a frown configuration for tranquil periods. Engström (2002) also found empirical evidence for the U-shaped smile for equity options written on Swedish stocks. Pan (2002) analysing stock index options quoted in the CBOE from 1989 to 1996 observed that jump models could accommodate a plausible assumption to justify a significant share of the smile. Wong and Tu (2009) studied the information content of option implied volatility and realized volatility under market imperfections in the context of GARCH modeling and volatility forecast of Taiwan stock market index ((TAIEX) returns. Other authors tried to extract superior information from the smile, as in Bates (1991), concluding that persistence on the smile pattern could imply that the market expected the 1987 crash.

Today it is common to justify the smile based on asymmetric and non-lognormal implied volatility distributions (see Hull, 2012). In order to match the empirical distributions several authors suggested models that accommodate jump, stochastic volatility or both, such as Gkamas and Paxson (1999), Das and Sundaram (1999), León and Rubio (2004) or Kuo (2011).

[1] Generalized auto regressive conditional heteroscedasticity.
[2] Exponentially weighted moving average.